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NASA CR- 144841

SOIL-MOISTURE GROUND TRUTH

HAND COUNTY, SOUTH DAKOTA
October 20, 1976

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(NASA-CR-144841) SOIL MOISTURE GROUND
TRUTH, HAND COUNTY, SOUTH DAKOTA, OCTOBER
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Mission Report--October 20, 1976, Mission

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INTRODUCTION

This report contains the ground-truth data taken at the Hand County, South Dakota, soil-moisture study site on October 20, 1976. The general location of this site is shown in Figure 1. These data were taken by M. W. Bittinger & Associates, Inc., personnel with assistance from Tom Schmugge, NASA-GSFC.

HAND COUNTY, SOUTH DAKOTA, SITE

The detailed location of the Hand County site is shown in Figure 2. Figure 3 shows the field numbering system used by NASA for this study site. The lines sampled for soil moisture during this mission are also shown in Figure 2. These are slightly different from the two previous missions. For the sake of clarity the lines have been indicated as "North," "Middle" and "South." It will be noted that these lines are not continuous in some cases but are line segments. These lines were established after a joint field review of cropping patterns, topography and prevailing local conditions.

Soil samples were taken in the field for later laboratory gravimetric analysis to determine soil moisture content. The typical sampling pattern used is illustrated in Figure 4. Samples were taken for three depths at each sampling point--0 to 1 (0 to 2.5cm) inch, 0 to 2 (0 to 5.1cm) inches, and 0 to 4 (0 to 10.2cm) inches.

SOIL-MOISTURE DATA

Soil types were determined from the Soil Survey of Hand County, South Dakota (White, Westin and Buntley 1963). The soil types encountered on the soil-moisture lines (Figure 2) are summarized in Table 1.

The actual soil-moisture data are presented in Tables 2 through 10. The data have been divided by range, township and section.

SOIL-TEMPERATURE DATA

Soil temperature measurements were taken by Tom Schmugge, of NASA-GSFC. These data are shown in Table 11. The primary depths at which temperatures were taken are 1.5cm, 4cm, 7cm, 10cm, and 14.5cm.

EXTRAPOLATION OF SOIL-MOISTURE DATA

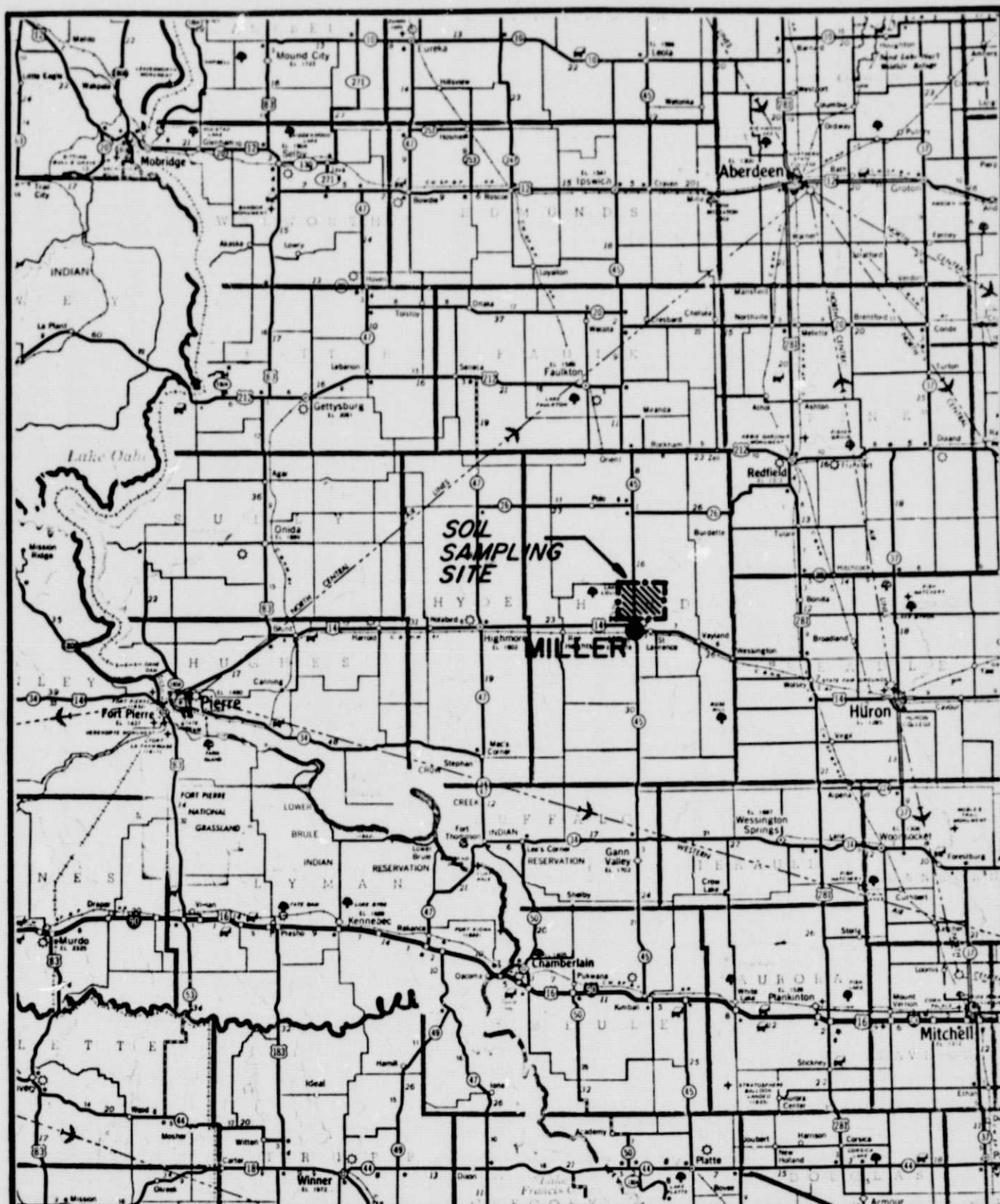
The bulk of the soil-moisture ground-truth data was taken on October 20, 1976, which was the date the aircraft was scheduled to fly. However, due to unforeseen problems with the airborne equipment, the aircraft did not fly this mission until October 22. For this reason some supplementary soil-moisture data in the 0- to 1-inch horizon were taken on October 21. The specific points sampled on both October 20 and 21 are summarized in Table 12. This table also shows the sample-point averages and the field averages for the dates of October 20 and 21. The statistical variability of the soil moisture is quite evident from this tabulation. In some instances the data indicate that the soil moisture increased from the 20th to the 21st. Such is not the case, for no new moisture, except possibly nighttime condensation, was added. This apparent increase is attributed to the small sample and difficulty in reoccupying the exact sites. The soil-moisture average for all points (36) on the 20th and 21st shows an average decrease of about 1 percent. This would appear to be appropriate and realistic; however, it took 36 samples to show this.

Further analyses of this nature were made by stratifying the soil moisture on the two dates by principal sampled soil types. These data are shown in Table 13. Again the problems of the small samples are evident.

Finally, the soil properties were reviewed for the major soil types which are presented in Table 14. This table shows that the 1/3 atmosphere moisture retention is about 24 to 35 percent. This value is approximately the "moisture equivalent" of the soil, which tends to be somewhat less than the maximum amount of water which can be held against the pull of gravity. Since the moisture ranges in the October 20th sampling are generally less than these values, there is little reason to expect major downward migration

of water, although some small amount would be expected to occur. The air temperatures at this time were between about 30 and 40 degrees Fahrenheit. This temperature would not produce a large amount of drying of the soil, although some surface drying would be expected. A check with the field crew members indicated that this was apparently correct.

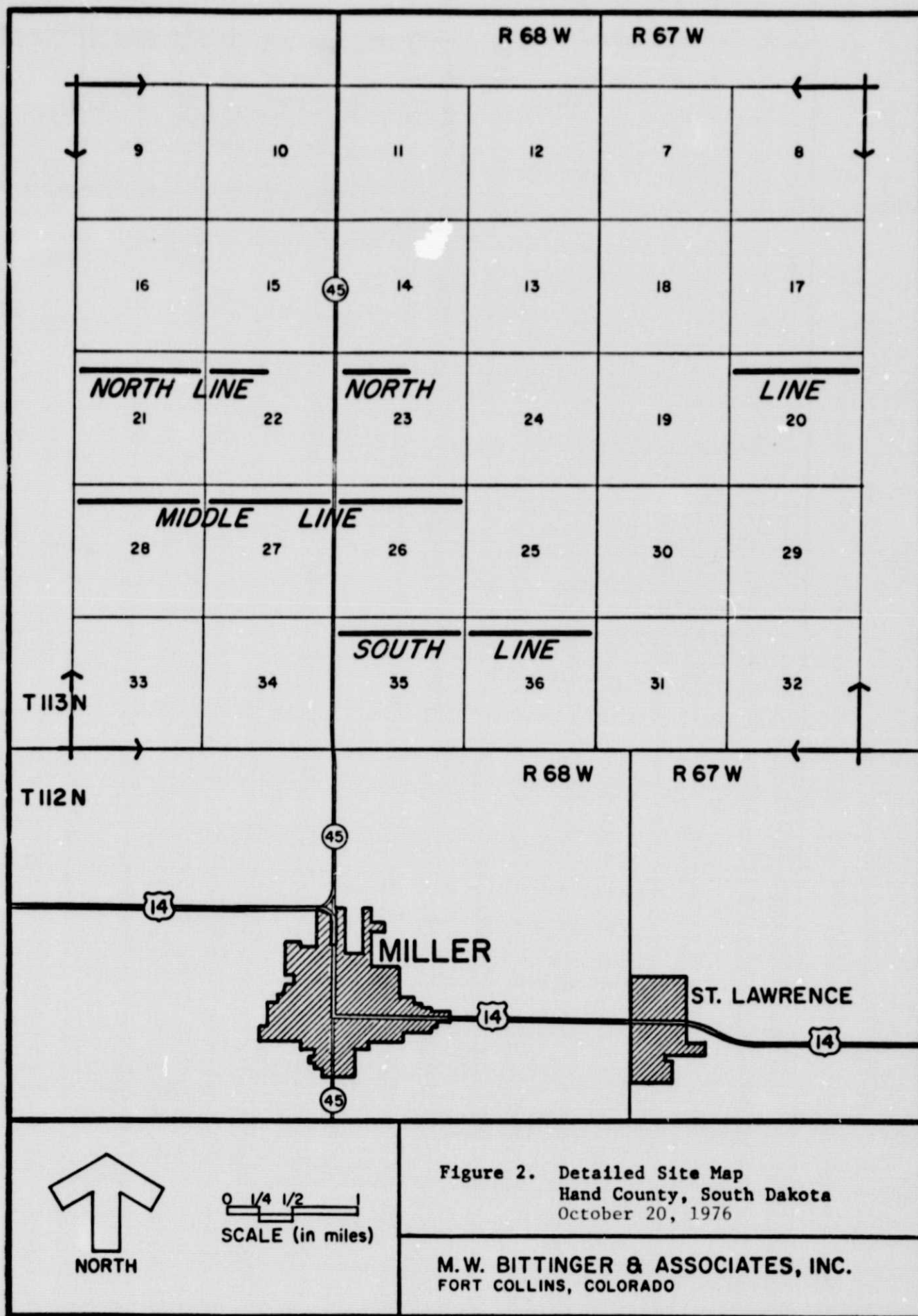
With this information the writer is of the opinion that "on the average" in the two days, for the upper 1 inch, one might expect a 20 percent soil moisture to decrease to about 18 percent. In cases where a high soil moisture initially occurred, it would drop more. It is suggested that a correction factor of 0.9 be applied. The degree of variability indicated would suggest that such a correction is well within the error band of estimation for most individual fields.



0 5 10 20
SCALE (in miles)

Figure 1. Site Location
Hand County, South Dakota

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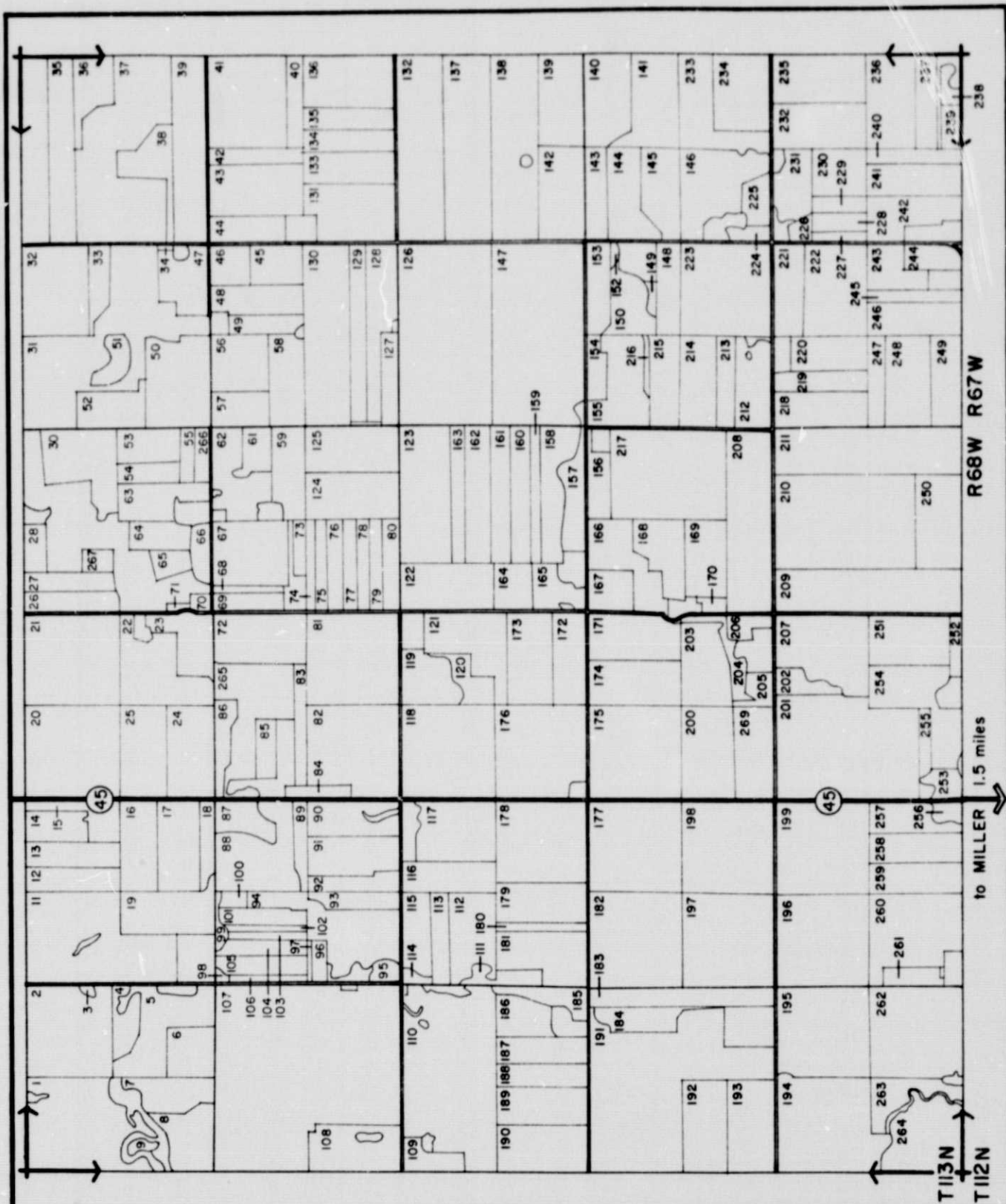
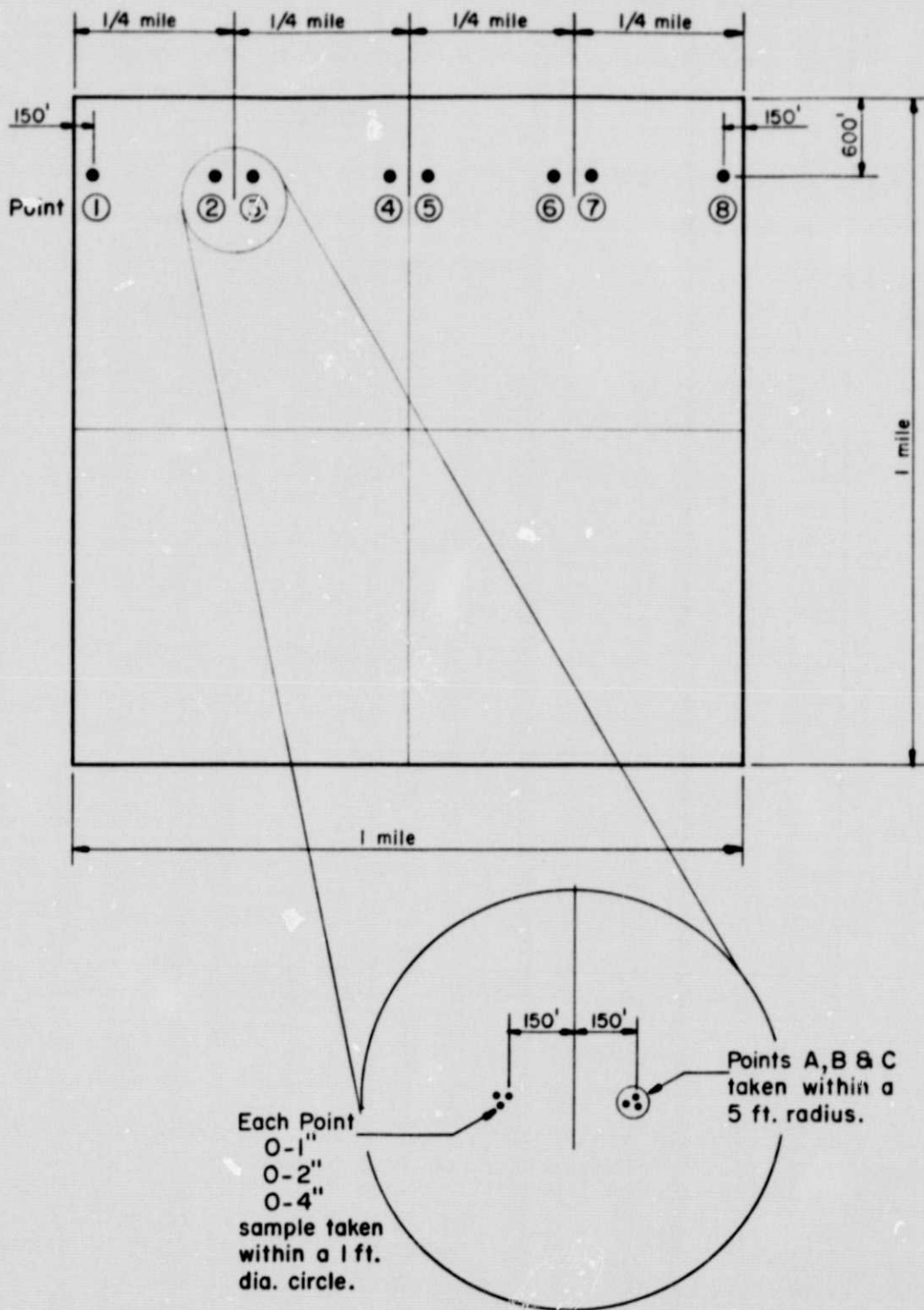


Figure 3. Site Field Numbers
Hand County, South Dakota

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FORT COLLINS, COLORADO



SCALE VARIES

Figure 4. Typical Sampling Pattern
Hand County, South Dakota
 October 20, 1976

M. W. BITTINGER & ASSOCIATES, INC.
 FORT COLLINS, COLORADO

Table 1

Soil Legend^{1/}

BcA - Bonilla-Cresbard loam, nearly level
ChA - Cavour-Houdek loams, nearly level
HhB - Houdek loam - undulating
HkA - Houdek-Bonilla loams, nearly level
HkB - Houdek-Bonilla loams, undulating
HlA - Houdek-Cavour loams, nearly level
HlB - Houdek-Cavour loams, undulating
HuD - Houdek-Zahl loams rolling
Hv - Hoven silty clay loam
LbA - LaDelle silt loam, nearly level
LeA - LaDelle-Aberdeen silty clay loams, nearly level
LLA - LaDelle-Lamoure silt loams, nearly level
MhA - Miranda-Houdek complex nearly level
Tw - Tetonka silt loam, somewhat poorly drained

^{1/}Ref: White, E. M., Westin, F. C. and G. J. Duntly, 1963.

Table 2

Soil Moisture Mission
October 20, 1976
Hand County, South Dakota Site
Data from North Line, Sec. 21 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	109	HhB	0-1	411	42.6	Fallow sod-plowed pasture organic dark soil
			0-2	422	29.5	
			0-4	419	19.5	
1B	109	HhB	0-1	432	28.4	
			0-2	409	19.0	
			0-4	405	15.4	
2A	110	HkB	0-1	406	26.5	Dark organic soil, disced stubble, fallow
			0-2	415	24.5	
			0-4	425	21.3	
2B	110	HkB	0-1	404	21.2	Disced stubble, fallow
			0-2	413	22.7	
			0-4	423	17.8	
3A	110	HkB	0-1	417	19.5	Same as above
			0-2	397	16.0	
			0-4	408	15.4	
3B	110	HkB	0-1	398	17.5	Same as above
			0-2	412	18.9	
			0-4	416	15.1	
4A	110	H1B	0-1	399	25.1	Same as above
			0-2	407	20.2	
			0-4	427	18.3	
4A	110	<i>H1B</i>	0-1	1149	11.4	<i>Winter wheat stubble, fallow</i>
4B	110	H1B	0-1	418	29.2	Disced stubble, fallow
			0-2	426	25.4	
			0-4	428	21.7	
4B	110	<i>H1B</i>	0-1	1150	20.7	<i>Winter wheat stubble, fallow</i>
5A	110	HkB	0-1	442	25.7	Disced stubble-fallow
			0-2	456	24.4	
			0-4	466	17.9	
5A	110	<i>Tw</i>	0-1	1151	12.1	<i>Winter wheat stubble, fallow</i>

*Items in italics are samples taken on October 21, 1976.

Table 2 (continued)

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from North Lines, Sec 21, Range 68W, Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
5B	110	HkB	0-1	438	22.7	Disced stubble-fallow
			0-2	445	25.2	
			0-4	452	14.0	
5B	110	Tw	0-1	1152	24.1	Winter wheat stubble, fallow
6A	110	HkB	0-1	449	21.5	Disced stubble-fallow
			0-2	454	21.7	
			0-4	460	11.2	
6A	110	HkB	0-1	459	24.7	Same as above
			0-2	455	25.5	
			0-4	453	19.6	
7A	110	HkB	0-1	434	21.6	Same as above
			0-2	439	15.2	
			0-4	451	12.7	
7B	110	HkB	0-1	433	17.9	Same as above
			0-2	435	20.5	
			0-4	458	13.5	
8A	110	HkB	0-1	462	22.9	Same as above
			0-2	446	19.4	
			0-4	457	16.3	
8B	110	HkB	0-1	443	20.8	Same as above
			0-2	467	17.8	
			0-4	463	17.3	

* Items in italics are samples taken on October 21, 1976.

Table 3

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from North Line, Sec. 22 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	114	L1A	0-1	384	22.0	Short oat and weed stubble
			0-2	395	22.0	
			0-4	389	21.2	
1B	115	L1A	0-1	373	20.7	Same
			0-2	393	20.8	
			0-4	390	19.5	
2A	115	HkB	0-1	381	20.4	Same
			0-2	366	20.1	
			0-4	367	18.7	
2B	115	HkB	0-1	365	21.3	Same
			0-2	354	20.9	
			0-4	383	19.1	
3A	115	HkA	0-1	374	20.4	Same
			0-2	363	20.4	
			0-4	377	19.1	
3B	115	HkA	0-1	254	20.1	Same
			0-2	387	19.3	
			0-4	394	17.6	
4A	115	HkA	0-1	380	23.7	Same
			0-2	386	24.4	
			0-4	388	21.3	
4B	115	HkA	0-1	391	24.4	Same
			0-2	392	22.4	
			0-4	396	21.7	

Table 4

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from North Line, Sec. 23 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	118	ChA	0-1	371	25.5	Disced, fallow, "old pasture"
			0-2	372	26.8	
			0-4	378	15.3	
1B	118	ChA	0-1	370	30.8	
			0-2	382	26.3	
			0-4	385	21.8	
2A	118	HkA	0-1	334	18.8	Same as above
			0-2	338	21.5	
			0-4	355	10.8	
2B	118	HkA	0-1	330	28.1	Same as above
			0-2	339	23.9	
			0-4	347	15.9	
3A	118	Hv	0-1	335	16.5	Same as above
			0-2	340	28.3	
			0-4	342	24.0	
3B	118	Hv	0-1	326	34.1	Same as above
			0-2	333	33.2	
			0-4	349	23.6	
4A	118	ChA	0-1	332	61.3	Same as above
			0-2	358	42.0	
			0-4	360	31.2	
4B	118	ChA	0-1	328	7.7	Same as above
			0-2	341	26.4	
			0-4	352	21.6	

Table 5
Soil Moisture Mission
October 20, 1976
Hand County, South Dakota Site
Data from North Line, Sec. 20 Range 67W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	132	ChA	0-1 0-2 0-4	296 289 290	29.8 23.1 22.4	70% snow cover up to 1" - surface moist - corn and organic matter stubble, mostly bare soil
1B	132	ChA	0-1 0-2 0-4	295 298 297	26.3 20.3 18.1	Surface very damp - 1" down, still very dry - at about 4", won't form ball
2A	132	HkA	0-1 0-2 0-4	261 256 257	23.9 23.0 16.2	Same as 20-4, surface little dryer
2B	132	HkA	0-1 0-2 0-4	259 266 262	21.8 21.6 16.0	Same as above
3A	132	HkA	0-1 0-2 0-4	258 265 260	24.5 22.1 17.3	Same as above
3B	132	HkA	0-1 0-2 0-4	255 263 264	26.5 23.2 20.9	Same as above
4A	132	H1A	0-1 0-2 0-4	292 293 300	27.5 21.3 16.7	50-60% snow cover - surface moist - corn and barley stubble mostly bare soil
4A	132	H1A	0-1	1142	26.2	<i>Wheat stubble</i>
4B	132	H1A	0-1 0-2 0-4	291 299 294	19.6 20.1 15.3	Surface little dryer than above - top mm very consistantly dry - corn & barley stubble
4B	132	H1A	0-1	1143	21.1	<i>Wheat stubble</i>
5A	132	H1A	0-1 0-2 0-4	305 304 309	30.5 27.0 18.1	Vegetation same as above, little surface drying, 40-50% snow cover

* Items in italics are samples taken on October 21, 1976.

Table 5 (continued)

Soil Moisture Mission

Hand County, South Dakota Site
Data from North Line, Sec. 20 Range 67W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
5A	132	H1A	0-1	1141	22.4	<i>Wheat stubble</i>
5B	132	H1A	0-1	303	17.3	Corn & barley stubble, little surface drying, 40-50% snow cover
			0-2	306	15.3	
			0-4	310	16.8	
5B	132	H1A	0-1	1144	27.8	<i>Wheat stubble</i>
6A	132	Tw	0-1	307	17.3	Corn & barley stubble, little surface dmying, 40-50% snow cover
			0-2	311	14.8	
			0-4	312	18.4	
6A	132	Tw	0-1	1145	19.7	<i>Wheat stubble</i>
6B	132	Tw	0-1	308	23.7	Corn & barley stubble, little more moist at surface
			0-2	301	20.7	
			0-4	302	14.1	
6B	132	Tw	0-1	1146	26.9	<i>Wheat stubble</i>
7A	132	Tw	0-1	313	19.2	Same as 20-4, gentle east facing slope
			0-2	317	16.0	
			0-4	318	16.3	
7A	132	Tw	0-1	1147	22.0	<i>Wheat stubble</i>
7B	132	Tw	0-1	314	19.3	Same as 20-4, gentle east facing slope
			0-2	323	16.0	
			0-4	324	12.9	
7B	132	Tw	0-1	1148	25.3	<i>Wheat stubble</i>
8A	132	Tw	0-1	316	22.2	Same as 20-4
			0-2	320	22.7	
			0-4	321	18.7	
8B	132	Tw	0-1	319	26.2	Same as above
			0-2	315	23.2	
			0-4	322	13.8	

* Items in italics are samples taken on October 21, 1976.

Table 6

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from Middle Line, Sec. 28 Range 6SW Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	191	HkB	0-1	274	39.3	Thick grass cover at surface, moist, top 1" mostly organic, 2" down very dry, 60-70% snow cover
			0-2	269	21.9	
			0-4	267	15.4	
1B	191	HkB	0-1	268	45.9	Same
			0-2	272	38.4	
			0-4	270	17.5	
2A	191	HkB	0-1	275	39.1	Same as above, organic matter 1-2" at top, 80-90% snow cover data missing
			0-2	277	19.4	
			0-4	276		
2B	191	HkB	0-1	271	18.3	Same as above, slightly dryer
			0-2	278	19.5	
			0-4	273	16.5	
3A	191	HkB	0-1	279	30.3	Same as above, surface mat of grass moist to wet, dry below
			0-2	276	25.4	
			0-4	281	19.5	
3B	191	HkB	0-1	280	43.2	Same as above
			0-2	285	42.4	
			0-4	279	25.0	
4A	191	HuD	0-1	288	26.9	Thick mat of grass, top 1-2" moist, dry below 2", snow cover 30-40%
			0-2	282	28.6	
			0-4	283	12.3	
4B	191	HuD	0-1	284	22.3	Same as above
			0-2	286	20.5	
			0-4	287	8.9	

Table 6 (continued)

Soil Moisture Mission
October 20, 1976
Hand County, South Dakota Site
Data from Middle Line, Sec. 28 Range 68N Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
5A	191	HuD	0-1	1403	42.4	Thick cover of grass, some taller, 3-5", some other vegetation, bottom of drainage, 10-20% snow cover
			0-2	1400	34.4	
			0-4	1399	13.9	
5B	191	HuD	0-1	1395	33.7	Same as above
			0-2	1404	25.6	
			0-4	1396	10.9	
6A	191	HhB	0-1	1394	41.9	Thick mat cover of grass, top 2" organic and moist, 30% snow cover, dry 2" down
			0-2	1397	20.5	
			0-4	1393	14.3	
6B	191	HhB	0-1	1398	31.1	Same as above
			0-2	1402	26.8	
			0-4	1401	22.3	
7A	184	HhB	0-1	1389	19.3	Surface fairly dry, wet down to 1-1½", top of furrow, bare ground with some corn stubble
			0-2	1381	18.3	
			0-4	1385	15.8	
7B	184	HhB	0-1	1390	29.8	Bottom of furrow pretty mucky, wet down to about 4", bare ground with some corn stubble
			0-2	1382	27.8	
			0-4	1386	22.8	
8A	183	HkB	0-1	1392	18.7	Top of furrow, top 1" with some moisture, bare ground with corn stubble
			0-2	1388	17.4	
			0-4	1384	14.6	
8B	183	HkB	0-1	1383	21.1	Bottom of furrow, moist down to about 3", bare ground with some stubble
			0-2	1391	18.8	
			0-4	1387	22.4	

Table 7

Soil Moisture Mission

October 20, 1976

Hand County, South Dakota SiteData from Middle Line, Sec. 27 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	182	HkB	0-1	1376	30.7	Bare ground with straw (wheat) top 1-1½" moist, 2" down, very dry, scattered snow 5-10%
			0-2	1372	26.8	
			0-4	1371	13.5	
1B	182	HkB	0-1	1379	35.1	Same as above except moisture down ½-1" further
			0-2	1380	20.4	
			0-4	1375	17.0	
2A	182	HkB	0-1	1373	19.7	Surface rather dry, rest same as 27-1A
			0-2	1369	17.8	
			0-4	1370	11.4	
2B	182	HkB	0-1	1377	35.8	Same as 27-1A
			0-2	1378	31.0	
			0-4	1374	24.5	
3A	182	HkB	0-1	51	15.3	Same as above except moisture just at surface, 2-5" clods, traces of snow
			0-2	53	14.4	
			0-4	52	16.1	
3B	182	HkB	0-1	57	33.4	Same as above except moisture down to about 3"
			0-2	54	31.5	
			0-4	62	25.5	
4A	182	HkA	0-1	351	22.8	Disced stubble - fallow
			0-2	474	20.3	
			0-4	481	15.8	
4A	<i>182</i>	<i>HkA</i>	<i>0-1</i>	<i>1129</i>	<i>14.7</i>	<i>Same as above</i>
4B	182	HkA	0-1	473	22.2	Same as above
			0-2	476	21.0	
			0-4	479	18.0	
4B	182	HkA	0-1	1130	23.2	<i>Same as above</i>

* Items in italics are samples taken on October 21, 1976.

Table 7 (continued)

Soil Moisture Mission
October 20, 1976
Hand County, South Dakota Site
Data from Middle Line, Sec. 27 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
5A	177	HkA	0-1 0-2 0-4	253 470 488	19.5 19.1 10.6	Winter wheat
5A	<i>177</i>	<i>HkA</i>	<i>0-1</i>	<i>1131</i>	<i>10.8</i>	<i>Disced stubble - fallow</i>
5B	177	HkA	0-1 0-2 0-4	348 353 368	15.3 14.9 16.3	Winter wheat
5B	<i>177</i>	<i>HkA</i>	<i>0-1</i>	<i>1132</i>	<i>22.5</i>	<i>Disced stubble - fallow</i>
6A	177	HkA	0-1 0-2 0-4	469 472 504	20.5 17.7 19.4	Winter wheat
6B	177	HkA	0-1 0-2 0-4	478 480 484	21.2 20.3 19.6	Winter wheat
7A	177	HkA	0-1 0-2 0-4	471 475 490	19.2 23.2 21.3	Winter wheat
7B	177	HkA	0-1 0-2 0-4	482 483 485	24.3 18.3 13.4	Winter wheat
8A	177	HkA	0-1 0-2 0-4	337 346 375	18.5 16.6 15.1	Winter wheat 3" high
8B	177	HkA	0-1 0-2 0-4	336 354 357	17.1 17.7 13.3	Winter wheat 3" high

* Items in italics are samples taken on October 21, 1976.

Table 8
Soil Moisture Mission
October 20, 1976
Hand County, South Dakota Site
Data from Middle Line, Sec. 26 Range 68W Township 13N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	175	HkA	0-1 0-2 0-4	345 486 497	26.0 22.7 19.1	Disced stubble - fallow
1B	175	HkA	0-1 0-2 0-4	501 493 494	15.5 16.7 12.5	Same as above
2A	175	ChA	0-1 0-2 0-4	508 510 511	15.5 19.0 15.5	Same as above
2B	175	ChA	0-1 0-2 0-4	506 507 509	24.7 21.4 18.9	Same as above
3A	175	ChA	0-1 0-2 0-4	514 515 516	21.0 22.4 20.0	Same as above
3B	175	ChA	0-1 0-2 0-4	517 518 519	19.6 15.8 15.0	Same as above
4A	175	ChA	0-1 0-2 0-4	505 512 513	13.8 14.6 13.8	Same as above
4A	<i>175</i>	<i>ChA</i>	<i>0-1</i>	<i>1133</i>	<i>18.8</i>	<i>Winter wheat stubble - fallow</i>
4B	175	ChA	0-1 0-2 0-4	526 527 528	25.0 24.2 21.4	Disced stubble - fallow
4B	<i>175</i>	<i>ChA</i>	<i>0-1</i>	<i>1134</i>	<i>24.2</i>	<i>Winter wheat stubble - fallow</i>
5A	174	ChA	0-1 0-2 0-4	521 522 523	28.4 24.1 21.0	Very weedy stubble

* Items in italics are samples taken on October 21, 1976.

Table 8 (continued)

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from Middle Line, Sec. 26 Range 68N Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
5A	174	ChA	0-1	1135	20.4	<i>Alfalfa, recently planted poor stand</i>
5B	174	ChA	0-1	520	26.7	Very weedy stubble
			0-2	524	25.6	
			0-4	525	19.0	
5B	174	ChA	0-1	1136	24.0	<i>Alfalfa, recently planted poor stand</i>
6A	174	LbA	0-1	529	26.4	Very weedy stubble
			0-2	535	24.5	
			0-4	538	18.3	
6B	174	LbA	0-1	530	23.7	Same as above
			0-2	536	23.7	
			0-4	537	21.4	
7A	171	LbA	0-1	532	22.9	Alfalfa 4" - 9"
			0-2	539	13.4	
			0-4	540	23.1	
7B	171	LbA	0-1	531	29.2	Same as above
			0-2	533	26.3	
			0-4	534	16.7	
8A	171	LbA	0-1	549	19.8	Thin Alfalfa 3" - 6"
			0-2	551	21.7	
			0-4	559	19.1	
8B	171	LbA	0-1	560	17.9	Same as above
			0-2	567	18.9	
			0-4	568	15.0	

* Items in italics are samples taken on October 21, 1976.

Table 9

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from South Line, Sec. 35 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	201	HkB	0-1 0-2 0-4	61 49 50	17.7 18.4 17.7	Winter wheat 2-3", top dry, moist rest of way
1B	201	HkB	0-1 0-2 0-4	56 63 60	26.6 26.9 24.7	Same as above but top moist
2A	201	H1A	0-1 0-2 0-3	65 67 76	17.7 17.0 11.1	Top of furrow, surface dry, winter wheat 2-3" tall, wet to about 1" down
2B	201	H1A	0-1 0-2 0-4	68 71 70	22.2 22.6 23.0	Winter wheat 2-3" Tall, surface moist, all 4" moist, forms small ball, bottom of furrow
3A	201	H1A	0-1 0-2 0-4	72 74 69	17.0 18.4 19.5	Same as 35-2A but slightly drier, fairly moist to 4"
3B	201	H1A	0-1 0-2 0-4	66 64 73	22.4 22.9 21.5	Moist at surface, same as 35-2A
4A	201	BhA	0-1 0-2 0-4	78 82 81	18.2 16.7 13.2	Sparse winter wheat, little moisture at surface, dry down to 4"
4A	201	BhA	0-1	1137	19.0	<i>Planted to winter wheat</i>
4B	201	BhA	0-1 0-2 0-4	77 85 86	24.6 26.1 23.1	Wet at surface, sparse winter wheat, moisture down to 3½"
4B	201	BhA	0-1	1138	17.2	<i>Planted to winter wheat</i>
5A	202	Tw	0-1 0-2 0-4	87 83 79	16.4 16.2 14.2	Surface dry, sparse winter wheat, some moderate moisture to 3"

* *Items in italics are samples taken on October 21, 1976.*

Table 9 (continued)

Soil Moisture Mission

October 20, 1976

Hand County, South Dakota SiteData from South Line, Sec. 35 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
5A	202	Tw	0-1	1139	17.6	<i>Planted to winter wheat</i>
5B	202	Tw	0-1	80	23.1	Surface wet, moisture to 5", sparse winter wheat
			0-2	84	22.9	
			0-4	88	22.6	
5B	202	Tw	0-1	1140	23.6	<i>Planted to winter wheat</i>
6A	207	LeA	0-1	184	20.5	Wet at surface, sparse winter wheat stubble & grass turned under, moisture down to 1"
			0-2	186	17.9	
			0-4	181	15.1	
6B	207	LeA	0-1	183	16.8	Surface drier than 35-6A, rest same as 35-6A
			0-2	189	15.2	
			0-4	182	11.3	
7A	207	LbA	0-1	199	17.3	Wet down to about ½", surface dry, dry from ½" down, sparse winter wheat, some wheat stubble & grass turned under
			0-2	193	19.9	
			0-4	194	15.8	
7B	207	LbA	0-1	198	33.2	Same as above, surface moist, wet down to 1½"
			0-2	197	26.8	
			0-4	195	16.0	
8A	207	LbA	0-1	196	19.5	Vegetation same as above, dry surface, wet to 1½", dry to bottom
			0-2	202	19.6	
			0-4	203	12.7	
8B	207	LbA	0-1	200	28.9	Moist at surface, moist to 4", vegetation same as 35-7A
			0-2	204	27.7	
			0-4	201	27.1	

* Items in italics are samples taken on October 21, 1976.

Table 10
Soil Moisture Mission
October 20, 1976
Hand County, South Dakota Site
Data from South Line, Sec. 36 Range 68E Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
1A	209	BcA	0-1 0-2 0-4	187 185 191	21.5 15.9 13.3	Top of furrow, surface dry moisture slight to 1", wheat & corn stubble, sparse winter wheat
1B	209	BcA	0-1 0-2 0-4	188 190 192	30.3 28.9 29.3	Same as above, moist top to 4", bottom of furrow
2A	209	BcA/Tw	0-1 0-2 0-4	213 214 215	14.2 15.8 14.7	Same as 36-1A
2A	<i>209</i>	<i>BcA/Tw</i>	<i>0-1</i>	<i>1117</i>	<i>17.0</i>	<i>Stubble from spring wheat- fallow</i>
2B	209	BcA/Tw	0-1 0-2 0-4	205 206 207	35.1 32.8 32.6	Same as 36-1B
2B	<i>209</i>	<i>BcA/Tw</i>	<i>0-1</i>	<i>1118</i>	<i>25.8</i>	<i>Stubble from spring wheat- fallow</i>
3A	210	BcA	0-1 0-2 0-4	208 209 210	19.3 17.2 9.9	Sparse winter wheat, wheat plowed under, stubble, wet down to 1"
3A	<i>210</i>	<i>BcA</i>	<i>0-1</i>	<i>1119</i>	<i>18.3</i>	<i>Stubble from winter wheat - fallow</i>
3B	210	BcA	0-1 0-2 0-4	211 212 216	31.1 31.2 29.4	Same as above, wet down to 4-5", bottom of furrow
3B	<i>210</i>	<i>BcA</i>	<i>0-1</i>	<i>1120</i>	<i>30.4</i>	<i>Stubble from winter wheat - fallow</i>
4A	210	BcA	0-1 0-2 0-4	1069 1070 1071	18.1 17.3 14.2	Same as 36-3A, top of furrow, top surface dry, next 1" wet

* Items in italics are samples taken on October 21, 1976.

Table 10 (continued)

Soil Moisture Mission

October 20, 1976

Hand County, South Dakota SiteData from South Line, Sec. 36 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
4A	210	BcA	0-1	1121	35.0	<i>Stubble from winter wheat - fallow</i>
4B	210	BcA	0-1	1072	32.1	Same as 36-3A, wet down to 3", bottom of furrow
			0-2	1073	29.6	
			0-4	1074	24.1	
4B	210	BcA	0-1	1122	18.1	<i>Stubble from winter wheat fallow</i>
5A	210	BcA	0-1	1075	9.3	Same as 36-3A, bottom of furrow, moisture down to
			0-2	1076	14.8	
			0-4	1077	15.1	
5A	210	BcA	0-1	1123	18.4	<i>Stubble from winter wheat, fallow</i>
5B	210	BcA	0-1	1078	42.3	Same as 36-3A, bottom of furrow, moisture down to 3-4"
			0-2	1079	35.5	
			0-4	1080	31.1	
5B	210	BcA	0-1	1124	28.0	<i>Stubble from winter wheat, fallow</i>
6A	210	HkA	0-1	545	17.5	Disced stubble, fallow
			0-2	554	20.0	
			0-4	561	11.3	
6B	210	HkA	0-1	548	29.2	Same as above
			0-2	553	26.7	
			0-4	574	19.7	
7A	211	BcA	0-1	546	21.3	Brome grass pasture
			0-2	550	21.4	
			0-4	552	20.7	
7A	211	BcA	0-1	1125	35.3	<i>Same as above</i>
7B	211	BcA	0-1	571	25.9	Same as above
			0-2	542	27.4	
			0-4	564	21.9	

* Items in italics are samples taken October 21, 1976.

Table 10 (continued)

Soil Moisture MissionOctober 20, 1976Hand County, South Dakota SiteData from South Line, Sec. 36 Range 68W Township 113N

<u>Point</u>	<u>NASA Field No.</u>	<u>Soil Type</u>	<u>Horizon (inches)</u>	<u>Soil Tin</u>	<u>Soil Moisture (%)</u>	<u>Remarks</u>
7B	211	BcA	0-1	1126	26.1	<i>Same as above</i>
8A	211	BcA	0-1	343	19.3	Over grazed pasture, Brome grass
			0-2	495	20.5	
			0-4	503	14.5	
8A	211	BcA	0-1	1127	24.5	<i>Brome grass pasture</i>
8B	211	BcA	0-1	502	26.6	Same as above
			0-2	541	26.9	
			0-4	572	19.4	
8B	211	BcA	0-1	1128	17.3	<i>Same as above</i>

* Items in italics are samples taken on October 21, 1976.

Table 11.

Soil Temperature Measurements
Hand County, Sout' Dakota
 (0°C)

Date Time	Field Depth	1.5 cm	4 cm	7 cm	10cm	14.5cm	Remarks
<u>10/19</u>							
5:10	177	6.9	6.4	6.2	6.5	6.6	
5:15	175	6.9	6.8	7.0	6.8	6.7	
5:30	126	5.3	5.9	7.1	8.3	7.9	
5:35	132	4.4	5.0	6.6	7.2	7.8	
<u>10/20</u>							
9:25	283(201)	2.5	1.3	3.1	4.1	5.0	
9:35	199	1.4	0.9	2.3	3.3	4.7	
9:46	177(peak)	2.3	0.9	2.0	3.1	4.8	
9:49	177(valley)	1.1	1.3	3.3	4.5	5.8	
9:56	177(valley)	0.9	1.0	2.8	4.1	5.5	
10:06	182	1.4	0.6	1.7	2.8	4.2	
10:22	191	3.7(air)	3.7(air)	3.1(1cm)	3.0(4.5)	4.3(9cm)	
10:55	286(115)	6.6	2.1	1.4	2.1	3.3	
11:13	118	6.1	0.2	0.6	2.4	4.9	
11:45	118	5.5	0.3	0.4	2.2	4.5	
12:07	174	7.8	5.2	3.4	3.6	4.8	
12:14	171	9.0	6.4	5.0	4.8	5.2	
12:32	209-210	6.2	6.7	5.7	5.6	5.9	
12:50	211	7.2	6.9	6.4	6.1	6.1	
1:09	177(peak)	8.7	7.4	5.9	5.3	5.5	
1:15	177(peak)	8.6	7.6	6.3	5.7	5.7	
1:18	177(valley)	10.1	8.3	6.6	6.3	6.7	
1:30	182	8.1	5.5	4.2	4.2	6.0	
1:53	182	8.2	6.4	5.0	4.7	5.9	
4:20	132 (moist valley)	6.9	7.3	7.8	7.6	7.4	
4:25	132 (dry ridge)	8.2	8.6	8.6	8.0	7.3	
4:45	171	7.7(air)	7.0(1cm)	7.5(4.5)	7.8(8cm)	7.8(12cm)	
<u>10/21</u>							
11:05	132	0.1	0.3	0.2	1.5	4.1	
<u>10/22</u>							
10:30	182	1.9	0.0	-0.1	0.7	4.1	
10:35	177(top)	4.0	0.0	0.0	1.4	3.9	
10:40	177(bottom)	1.4	0.3	1.5	2.7	5.1	
11:00	210	2.0	0.0	0.6	1.7	3.5	
11:05	211	5.3	1.1	1.2	1.9	3.5	
11:10	210	1.8	0.9	1.8	2.7	4.1	2" away from 11:00 read in.

Table 11 (continued)

Date Time	Field Depth	1.5 cm	4 cm	7 cm	10 cm	14.5 cm	Remarks
10/22	(continued)						
11:22	210	2.0	0.5	1.1	2.1	3.7	
11:30	210	2.5	0.5	1.0	1.9	3.6	
11:35	210	3.0	0.6	0.8	1.8	3.6	
11:45	210	3.4	1.0	1.4	2.5	3.7	Surface 1/2" still moist in wet spots
11:50	210	3.5	1.1	1.6	2.7	3.8	
12:00	210	3.8	1.2	1.6	2.7	3.8	P-3 overhead
12:04	210	4.1	1.2	1.3	2.3	3.6	
12:45	126	6.8	1.9	0.6	1.7	4.6	
1:23	West of 191	9.4	6.1	1.9	2.1	4.0	Fallow
1:40	West of 194 (top)	13.5	9.5	5.6	3.7	4.0	Planted
1:45	West of 194 (bottom)	12.2	6.4	4.2	3.7	5.8	

Table 12

Hand County, South Dakota

Sample Points Repeated on October 22, 1976

	R.	T.	S.	NASA Field	Point	Soil Type	Field Cover	Depth (in.)	% Soil Moisture		Point Average		Field Average	
									Oct. 20	Oct. 21	Oct. 20	Oct. 21	Oct. 20	Oct. 21
1	68W	113N	21	110	4A	H1B	Wheat stubble	0-1	25.1	11.4	27.2	16.1		
2				110	4B	H1B	" "	0-1	29.2	20.7			25.7	17.1
3				110	5A	Tw	" "	0-1	25.7	12.1	24.2	18.1		
4				110	5B	Tw	" "	0-1	22.7	24.1				
5	67W	113N	20	132	4A	H1A	Corn stubble	0-1	27.5	26.2	23.6	23.7		
6				132	4B	H1A	wheat stubble	0-1	19.6	21.1				
7				132	5A	H1A	" "	0-1	30.5	22.4	23.9	25.1		
8				132	5B	H1A	" "	0-1	17.3	27.8			21.8	23.9
9				132	6A	Tw	" "	0-1	17.3	19.7	20.5	23.3		
10				132	6B	Tw	" "	0-1	23.7	26.9				
11				132	7A	Tw	" "	0-1	19.2	22.0	19.3	23.7		
12				132	7B	Tw	" "	0-1	19.3	25.3				
13	68W	113N	27	182	4A	HkA	Disced fallow	0-1	22.8	14.7	22.5	19.0	22.5	19.0
14				182	4B	HkA	" "	0-1	22.2	23.2				
15				177	5A	HkA	" "	0-1	19.5	10.8	17.4	16.7	17.4	16.7
16				177	5B	HkA	" "	0-1	15.3	22.5				
17	68W	113N	26	175	4A	ChA	" "	0-1	13.8	18.8	19.4	21.5	19.4	21.5
18				175	4B	ChA	" "	0-1	25.0	24.2				
19				174	5A	ChA	Alfalfa-weedy	0-1	28.4	20.4	27.6	22.2	27.6	22.2
20				174	5B	ChA	stubble	0-1	26.7	24.0				
21	68W	113N	35	201	4A	BhA	Winter wheat	0-1	18.2	19.0	21.4	18.1	21.4	18.1
22				201	4B	BhA	" "	0-1	24.6	17.2				
23				202	5A	Tw	" "	0-1	16.4	17.6	19.8	20.6	19.8	20.6
24				202	5B	Tw	" "	0-1	23.1	23.6				
25	68W	113N	36	209	2A	BcA/Tw	Stubble-Misc.	0-1	14.2	17.0	24.7	21.4	24.7	21.4
26				209	2B	BcA/Tw	" "	0-1	35.1	25.8				
27				210	3A	BcA	Winter Wheat Stubble	0-1	19.3	18.3	25.2	24.4		
28				210	3B	BcA	" "	0-1	31.1	30.4				
29				210	4A	BcA	" "	0-1	18.1	35.0	25.1	26.6	25.4	24.7
30				210	4B	BcA	" "	0-1	32.1	18.1				
31				210	5A	BcA	" "	0-1	9.3	18.4	25.8	23.2		
32				210	5B	BcA	" "	0-1	42.3	28.0				
33				211	7A	BcA	Pasture	0-1	21.3	35.3	23.6	30.7		
34				211	7B	BcA	" "	0-1	25.9	26.1			23.3	25.8
35				211	8A	BcA	" "	0-1	19.3	24.5	23.0	20.9		
36				211	8B	BcA	" "	0-1	26.6	17.3				
									\bar{x}	23.0	21.9			
									S.D.	6.6	5.7			

Table 13.
Soil Moisture by Soil Types
Hand County, South Dakota
(0 to 1 inch)

Tw-Tetonka Silt Loam

<u>Field</u>	<u>Point</u>	<u>Oct. 20</u>	<u>Oct. 21</u>
110	5A	25.7	12.1
110	5B	22.7	24.1
132	6A	17.3	19.7
132	6B	23.7	26.9
132	7A	19.2	22.0
132	7B	19.3	25.3
202	5A	16.4	17.6
202	5B	23.1	23.6
	\bar{x}	20.9	21.4
	S.D.	3.3	4.8

BcA-Bonilla-Cresbard Loam

<u>Field</u>	<u>Point</u>	<u>Oct. 20</u>	<u>Oct. 21</u>
210	3A	19.3	18.3
210	3B	31.1	30.4
210	4A	18.1	35.0
210	4B	32.1	18.1
210	5A	9.3	18.4
210	5B	42.3	28.0
211	7A	21.3	35.3
211	7B	25.9	26.1
211	8A	19.3	24.5
211	8B	26.6	17.3
	\bar{x}	24.5	25.1
	S.D.	9.2	7.0

Table 13. (continued)

H1A-Houdek-Cavour Loams

<u>Field</u>	<u>Point</u>	<u>Oct. 20</u>	<u>Oct. 21</u>
132	4A	27.5	26.2
132	4B	19.6	21.1
132	4A	27.5	26.2
132	5B	17.3	27.8
	\bar{x}	23.7	24.4
	S.D.	6.3	3.2

HkA-Houdek-Bonilla Loams

<u>Field</u>	<u>Point</u>	<u>Oct. 20</u>	<u>Oct. 21</u>
182	4A	22.8	14.7
182	4A	22.2	23.2
177	4B	19.5	10.8
177	4B	15.3	22.5
	\bar{x}	20.0	17.8
	S.D.	3.4	6.1

ChA-Cavour-Houdek Loams

<u>Field</u>	<u>Point</u>	<u>Oct. 20</u>	<u>Oct. 21</u>
175	4A	13.8	18.8
175	4B	25.0	24.2
174	5A	28.4	20.4
174	5B	26.7	24.0
	\bar{x}	23.5	21.9
	S.D.	6.6	2.7

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Table 14.

Soil Properties for Selected Soils
Hand County, South Dakota ^{1/}

<u>Soil</u>	<u>Horizon</u>	<u>Depth</u> (in.)	<u>USDA Texture</u>	<u>Available</u> <u>Water-holding</u> <u>Capacity</u> (in./in. of soil)	<u>SCS</u> <u>Hydrologic</u> <u>Soil group</u>	<u>% Moisture held at</u> ^{2/}		
						<u>1/10 Atmos.</u>	<u>1/3 Atmos.</u>	<u>15 Atmos.</u>
Bonilla loam or silt loam	A1	0-6	Loam to silt loam	0.13 to 0.20	B	--	31.6	19.0
Cavour loam or silt loam	A1	0-5	Loam to silt loam	0.13 to 0.20	D	--	35.0	9.2
Cresbard silt loam or loam	A1	0-8	Silt loam to loam	0.14 to 0.21	C	--	28.2	15.0
Houdek loam	A1	0-6	Loam	0.13 to 0.20	B	--	23.7	13.7
Hoven	A1-A2	0-3	Silty clay loam	0.14 to 0.21	D	--	--	--
	B2	3-9	Silty clay to silty clay loam	0.14 to 0.21				
LaDelle silt loam	A1	0-5	Loam	0.13 to 0.20	B	49.5	29.9	13.7
Miranda Silt loam or loam	A1	0-3	Silt loam to loam	0.14 to 0.21	D	--	--	--
	B2	3-7	Silty clay loam	0.14 to 0.21				
Tetonka silt loam	A1	0-4	Silt loam	0.14 to 0.21	C	--	--	--

^{1/} Ref: White, E. M., Westin, F. C. and G. J. Buntley 1963

^{2/} Note 1/3 atmosphere tension approximates moisture equivalent which is generally less than field capacity and 15 atmospheres approximates the permanent wilting point. (Baver 1961)

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